HIGH PERFORMANCE COMPUTING FOR NATIONAL SECURITY AND COMPETITIVE STRENGTH (HPC-NSCS)

University of Southern California

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14. ABSTRACT
The goal of this effort was to stimulate and facilitate wider usage of high performance computing (HPC) across the private sector to propel productivity, innovation, and competitiveness. The council on Competitiveness (Council) confirmed 14 industrial / 1 Museum executives to give presentations at SC07, the annual international supercomputing conference to be held November 12-16, 2007. Presentations focused on how their organizations are using high performance computing to drive competitive advantage. The Council targeted four Masterworks speakers representing Ping Golf, Whirlpool, Goodyear, and Pioneer Hi-Bred to conduct case studies on the business and competitiveness value they have received from using HPC. Case studies explain in laymen's terms the problems these firms solved and the returns they achieved are necessary and important tools for "building the business case" for HPC and expanding its use across the U.S. industrial base, particularly among small and mid-sized companies that are in DoD's supply chain but have not yet embraced this technology.

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1.   Summary

The following is the final report for the project entitled High Performance Computing for National Security and Competitive Strength (HPC-NSCS). The Council on Competitiveness (Council) and the University of Southern California's Information Sciences Institute (ISI) teamed on this effort. The goal of this effort was to stimulate a wider usage of high performance computing (HPC) across the private sector in order to propel productivity, innovation and competitiveness.

The specific objectives of HPC-NSCS were to:

1. Analyze the economic rationale for sustaining U.S. leadership in HPC, especially the impact upon manufacturing, services, business, and state-of-the-art research capabilities,

2. Identify key private sector HPC applications needs and priorities,

3. Identify workforce education and training needs to integrate HPC in the private sector, and

4. Foster public-private sector partnerships to better leverage resources and expertise to help overcome barriers to more widespread private sector usage of HPC.

There were two major activities under this effort:

- *HPC Advisory Committee* – The HPC-NSCS team brought together a dedicated group of 40 executives representing private and public sector HPC users, hardware and software developers, and government agencies. The committee is a national "brain trust" of senior leaders that use and fund development of HPC. The HPC-NSCS team utilized the committee's collective expertise to guide the overall effort in achieving the program objectives.

- *HPC Users Conference* – The HPC-NSCS team supported the Masterworks sessions at the Supercomputing 2007 (SC07) conference. The team recruited 14 industrial executives and 1 museum executive to give presentations at SC07 as part of the Masterworks track. Presentations focused on how their organizations are using high performance computing to drive competitive advantage. This activity was the main focus of the team in order to stimulate a wider usage of HPC across the private sector.

The results of this effort have provided valuable insight into unique private sector user needs that DARPA should consider in order to enhance market receptivity of the future products of the High Productivity Computing Systems (HPCS) program. The strength or weakness of the market's acceptance of the HPCS program output will effect dramatically the return that the Government will achieve from this multi-year effort and will have a significant bearing on the amount of future investment required to sustain U.S. superiority in high performance computing, and ensure that DOD and other government agencies have the systems they need to meet their mission critical requirements.

The HPC-NSCS approach leveraged the best thinking and insights of the public and private sectors. The results of this effort helped identify the barriers preventing more widespread access to and usage of HPC, and thereby gauged the country's ability to drive innovation across the economy. The results of this study helped illuminate the steps the public and private sectors need to take individually and in collaboration to expand HPC usage and help this important market to grow. Market growth, in turn, will help reduce the cost of HPCS systems and software, benefiting DARPA, DOD, U.S. industry and the country.

2.   Introduction

The following is the final report for the project entitled High Performance Computing for National Security and Competitive Strength (HPC-NSCS) performed by the University of Southern California's Information Sciences Institute (ISI) and the Council on Competitiveness (Council). The following final report covers the full period of performance of this effort, from 8/22/2007 to 9/30/2008.

3.   Methods, Assumptions, and Procedures

This goal of this project was to stimulate and facilitate wider usage of high performance computing (HPC) across the private sector in order to propel productivity, innovation and competitiveness. The specific objectives of the effort were to: 1) analyze the economic rationale for sustaining U.S. leadership in HPC, especially the impact upon manufacturing, services, business, and state-of-the-art research capabilities, 2) identify key private sector HPC applications needs and priorities, 3) identify workforce education and training needs to integrate HPC in the private sector, and 4) foster public-private sector partnerships to better leverage resources and expertise to help overcome barriers to more widespread private sector usage of HPC. There were two major activities under this effort:

3.1   HPC Advisory Committee

The Council on Competitiveness has brought together a dedicated group of 40 executives, the HPC Advisory Committee, representing private and public sector HPC users, hardware and software developers, and government agencies. The purpose of this group is: 1) to gain insights into how the private sector currently use advanced computing capabilities, 2) to assess future needs and opportunities to integrate advanced computing into their operations, and 3) to understand their issues and priorities with respect to designing next-generation systems. This committee is a national "brain trust" of industrial HPC users, universities, computer hardware and software developers, and federal agencies/national laboratories that use and fund development of HPC. On behalf of the HPCS program, the HPC-NSCS team coordinated with the HPC Advisory Committee and hosted their annual meeting on May 6, 2008.

The results are described in Section 4.1.

3.2   HPC Users Conference

The HPC-NSCS team coordinated with the planning committee of the annual international supercomputing conference, Supercomputing 2007 (SC07) to create an industry-focused 2007 Masterworks session in support of the goal of stimulating future industrial users of HPCS-derived systems. The Masterworks session at SC07 included 15 technical presentations over three days about new and novel uses of HPC. The HPC-NSCS team worked with the Masterworks planning committee to frame the technical program to focus on high leverage industrial problems that are being addressed with HPC. The team and the Masterworks co-chairs identified and invited industrial users to participate in SC07, creating a unique event that focuses on the application of HPC for competitive advantage. The HPC-NSCS team also utilized the Council's HPC Advisory Committee membership to encourage industrial attendance, particularly the senior level public and private sector executives that had been attending the Council on Competitiveness' HPC Users Conference in the three prior years (2004-2006). While SC07 usually focuses on how to "build a better computer", the HPC Users Conferences historically provided a forum to highlight the opportunities to accelerate U.S. competitiveness by applying HPC as has been documented by Council publications [1]-[19]. The HPC-NSCS team introduced this competitiveness theme to the Masterworks session at SC07.

The results of this activity are described in Section 4.2.

4. Results and Discussions

4.1 HPC Advisory Committee

4.1.1 Annual HPC Advisory Committee Meeting

The HPC Advisory Committee meeting was held on May 6, 2008. Over forty committee members attended. This "brain trust" provided the substantive guidance to the HPC-NSCS team to facilitate wider usage of HPC across the private sector to propel productivity, innovation and competitiveness. At this meeting, the members discussed the economic rationale for sustaining U.S. leadership in HPC, especially the impact upon manufacturing, services, business, and state-of-the-art research capabilities. They identified key needs and priorities for integrating HPC in the private sector. Specific topics covered in the meeting included:

- Major accomplishments during the previous year were reviewed, including: two new studies on desktop-to-HPC-server migration [18][19], status of the Masterworks presentations at SC07 and the Chief Technology Officer (CTO) Roundtable, and the HPC Application Software Consortium Summit held at the National Center for Supercomputing Applications (NCSA).

- Business metrics for innovation capacity were discussed. It was reported that the typical economic development metric is skewed toward job creation in small start-ups. Economic development officials are often unfamiliar with HPC and even unaware of the HPC centers in their regions, often overlooking them when assessing their portfolio of regional assets. The members brainstormed ways to educate economic development officials on the value of university and national lab HPC centers in their geographic areas and how to stimulate cooperation between these two communities.

- There was discussion on making modeling, simulation and large-scale data analysis with HPC a best business practice. The members recommended launching a national awareness campaign on this topic. HPC is a game-changing technology, but its use is uneven across the private sector, featuring a small group of experienced high-end users, many desktop users, and a "missing middle" in between these two groups. The HPC-NSCS team incorporated this recommendation into the overall theme of the SC07 Masterworks sessions.

- The HPC-NSCS team reported on the HPC Application Software Summit held at NCSA. The goal of the summit was to explore creation of a consortium to develop and maintain a framework for multiphysics simulation on HPC systems using commercial and open-source codes.

4.1.2 HPC Application Software Summit

The HPC-NSCS team provided technical guidance for an HPC Application Software Summit at the National Center for Supercomputer Applications. Over 100 executives and researchers representing leading HPC users, independent software vendors (ISVs), national labs and DoD attended and many HPC Advisory Committee members attended and participated on panel discussions. The Summit was prompted by the growing need for companies to solve complex, multidisciplinary problems in order to advance their global competitive position. Users expressed concern that appropriate software is lacking, which are stalling firms, from doing the full, life cycle systems simulations needed to create world-class products.

This summit revealed the challenges of adapting/creating application software, particularly from the independent software vendors' perspective, for future petascale systems. The summit identified an opportunity for collaboration among key HPC researchers and developers across the private and public sectors for working collaboratively to address this hurdle.

4.2 HPC Users Conference

4.2.1 SC07 Masterworks Sessions

The HPC-NSCS team confirmed 14 industrial and one museum executive to give presentations at SC07, the annual international supercomputing conference held November 12-16, 2007. Presentations focused on how their organizations are using high performance computing to drive competitive advantage.

Presentations included:

- "High Performance Computing: Shaping the Future of Formula One", Torbjörn Larsson, BMW

- "HPC at Chrysler: Bringing NASCAR from the Race Track to Your Driveway", John Picklo, Chrysler

- "Child's First Words, Terrible Teens and My Boring Parents: Prediction in the Complex World of Crop Genetic Improvement", Mark Cooper, Pioneer Hi-Bred

- "Diverse Energy Sources for Better Driving", Sharan Kalwani, General Motors

- "A Grand Challenge: MultiCore and Industrial Modeling and Simulation", Jamil Appa, BAE Systems

- "HPC in the Kitchen and Laundry Room: Optimizing Everyday Appliances for Customer Satisfaction and Market Share", Clifford Hutton, Whirlpool Corporation.

- "Rendering at the Speed of Shrek", Evan Smyth, DreamWorks Animation

- "Turbo Charging Gas Turbine Engine Development: How Pervasive Supercomputing Is Helping Pratt & Whitney Develop a "Greener" Jet Engine", Peter Bradley, Pratt & Whitney

- "HPC Comes to Hollywood: Birth of a New Industry", Robert Eicholz, EFILM, LLC

- "A Tiger by the Tail: HPC Designs High Performance Golf Clubs", Eric Morales, PING Golf

- "High Performance Computing: Pragmatism In the Corporate World", Anthony L. Abbattista and Catherine S. Brune, Allstate Insurance Company

- "From the Earth to the Stars: Supercomputing at the Hayden Planetarium", Mordecai-Mark Mac Low, American Museum of Natural History

- "From the Molecule to the Pump: Global Energy Supply Chain Optimization with HPC for Maximum Energy Security", Lynn Chou, Chevron Information Technology Company

- "Jolt: Accelerating the Rate of New Product Innovation", Loren Miller, The Goodyear Tire & Rubber Company

Masterworks attendance for each talk ranged from 50 to nearly 250 depending on the topic.

4.2.2 Chief Technology Officer (CTO) Round Table at Masterworks

The HPC-NSCS team added a new CTO Roundtable session as part of the Masterworks program with the approval of the SC07 Planning Committee. This capstone session explored the strategic value of HPC, and how this critical asset is best positioned to contribute maximum business return for competitive gain.

The speakers for this round table included:

- Anna Ewing, Executive Vice President of Operations and Technology and Chief Information Officer of The Nasdaq Stock Market, Inc.

- Kevin Humphries, Senior Vice President of Technology Systems, FedEx Corporate Services

- Reza Sadeghi, Chief Technology Officer, MSC Software

- Nancy Stewart, Senior Vice President and Chief Technology Officer, Wal-Mart Stores, Inc.

The CTOs discussed a range of strategic issues related to their company's use of HPC and the barriers that prevent them from more aggressive application of computing. The insights offered a glimpse into how several of the nation's top corporations have recognized the value of HPC at the highest levels of the company and how they are managing it as a strategic asset for maximum return on investment.

4.2.3 Masterworks Case Studies

The HPC-NSCS team interviewed four Masterworks speakers representing Ping Golf, Whirlpool, Goodyear, and Pioneer Hi-Bred to document case studies on the business and competitiveness value they have received from using HPC. The case studies [20]-[23] explain in laymen's terms the problems these firms solved and the returns they achieved are necessary and important tools for "building the business case" for HPC and expanding its use across the U.S. industrial base, particularly among small and mid sized companies that are in DOD's supply chain but have not yet embraced this technology. These case study reports have been delivered to AFRL for review and have been approved for release.

5.   Conclusions

There is a tremendous lack of published information on the importance of modeling and simulation with HPC to business success and competitiveness. The presentations at Supercomputing 2007 and the subsequent case studies supported by this effort attempt to fill this gap by explaining in laymen's terms the problems these firms solved and the returns they achieved. Such studies are necessary and important for "building the business case" for HPC and expanding its use across the U.S. industrial base, particularly among the small and medium size companies that form a significant portion of DOD's supply chain but have not yet embraced the technology.

6.   Recommendations

Future outreach activities and broad dissemination of these studies will be crucial for advancing the business case for HPC, expanding its use across the U.S. industrial base and within the DOD supply chain, and increasing public awareness of the competitiveness benefits of using HPC.

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8.   Acronyms

AFRL	Air Force Research Laboratory
BWM	Bavarian Motor Works
CEO	Chief Executive Officer
CFD	Computational Fluid Dynamics
CFO	Chief Financial Officer
CIO	Chief Information Officer
CTO	Chief Technology Officer
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
FEA	Finite Element Analysis
FedEx	Federal Express, Inc.
HPC	High Performance Computing
HPCS	High Productivity Computing Systems
INCITE	Innovative and Novel Computational Impact on Theory and Experiment
ISI	Information Sciences Institute
ISV	Independent Software Vendor
IT	Information Technology
LLC	Limited Liability Corporation
NCSA	National Center for Supercomputing Applications
NSF	National Science Foundation
P&W	Pratt & Whitney
R&D	Research & Development
ROI	Return on Investment
SC07	Supercomputing 2007
U.S.	United States
USC	University of Southern California
VLSI	Very Large Scale Integrated Circuits